Manufacturing Readiness Levels (MRLs)
Manufacturing Readiness Assessments (MRAs)

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Report Documentation Page

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Why MRLs?

"Advanced weapon systems cost too much, take too long to field, and are too expensive to sustain" -- Congress, OSD, CSAF, GAO

- Production/manufacturing processes are major contributor
  - Recent GAO study of core set of 26 programs: RDT&E costs up by 42% and schedule slipped by 20%
    - $42.7B total cost growth
    - 2.5 years average schedule slip
  - Characteristics of successful programs:
    - *Mature technologies, stable designs, production processes in control*
    - *S&T organization responsible for maturing technologies, rather than program or product development manager*
- Need way to mitigate impact of diminishing manufacturing infrastructure
  - People, policy, programs gutted
  - Lost recipe on how to manage manufacturing risk
  - Won't get infrastructure back but still need to manage manufacturing risk

Technology Readiness Levels
(TRLs)

Provide a common language and widely-understood standard for:

- Assessing the *performance maturity* of a technology and plans for its future maturation
- Understanding the level of performance risk in trying to transition the technology into a weapon system application

TRLs leave major transition questions unanswered:

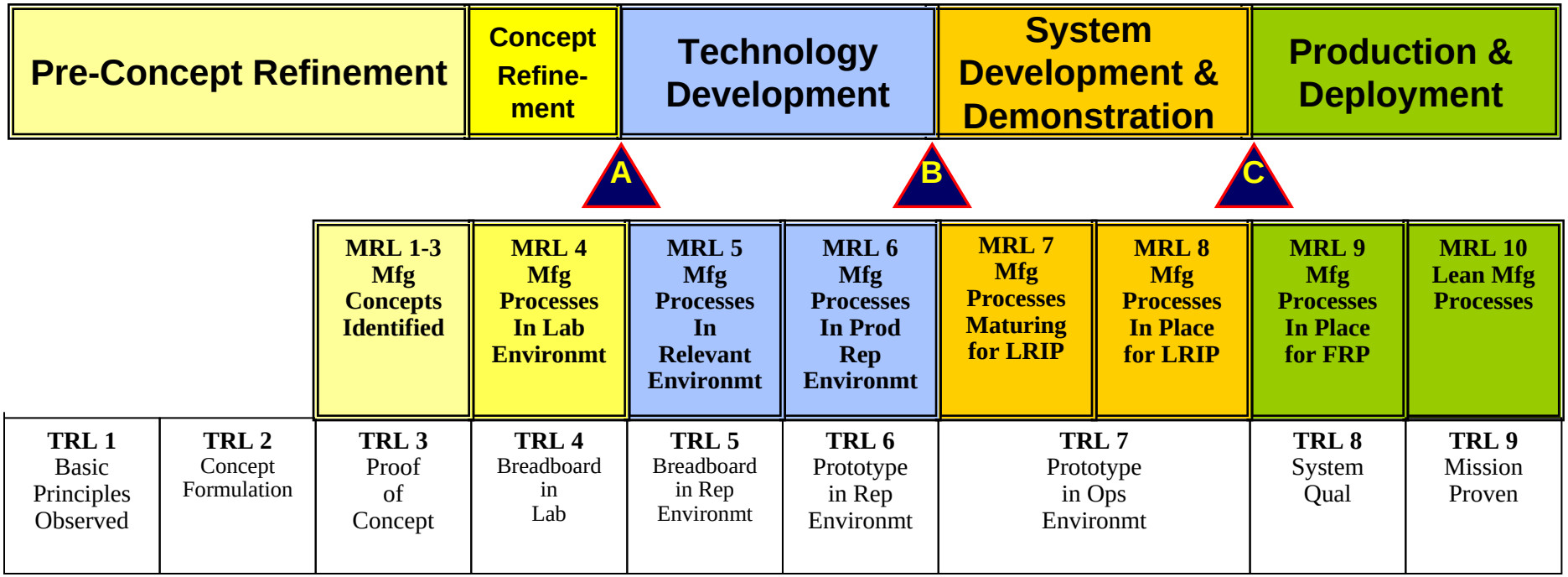
- Is the technology producible? Reproducible?
- What will these cost in production?
- Can these be made in a production environment?
- Are key materials and components available?

Manufacturing Readiness Levels (MRL)

- Common language and standard for
  - Assessing the ***manufacturing maturity*** of a technology or product and plans for its future maturation
  - Understanding the level of manufacturing risk in trying to produce a weapon system or transition the technology into a weapon system application
- Designed to complement TRLs
- Designed to help set the agenda for manufacturing risk mitigation
- Usage
  - Army, for Future Combat Systems development efforts
  - Missile Defense Agency using EMRLs on all development programs
  - Several defense primes using on weapon system programs
  - ***Mandated by AFRL for phase-in on all hardware ATDs***

MRL Relationships

Relationship to System Acquisition Milestones



Relationship to Technology Readiness Levels

MRL Evaluation Criteria (Threads)

- Technology and Industrial Base
- Design
- Materials
- Cost and Funding
- Process Capability and Control
- Quality Management
- Manufacturing Personnel
- Facilities
- Manufacturing Management

MRL Evaluation Criteria (Threads)

Acq Phase		Pre CR	CR - MS A →	TD	MS B →
Criteria	Metric	MRL 1-3	MRL 4	MRL 5	MRL 6
Technical	**Technical**	TRLs 1-3	Must be assessed at minimum of TRL 4.	Must be assessed at minimum of TRL 5.	Must be assessed at minimum of TRL 6.
Technology & Industrial Base	**TECHNOLOGY TRANSITION TO PRODUCTION)**	Identify technology leadership as potential sources (foreign/domestic); (commercial/government)	IB capabilities and gaps/risks identified for key technologies.	Industrial Base analysis accomplished to identify potential sources.	IB capability in place to support mfg of development articles. IB exists for similar components or plan developed for developing facilities.
Design	**Producibility Program**		Initial producibility assessment of design completed.	Initial producibility of technology completed (components).	Initial producibility of technology completed (systems level). Initial trade studies conducted - performance vs. producibility.
	Form, Fit, & Function		Initial Form, Fit, & Function constraints identified and allocated.	Form, Fit, & Function constraints identified and allocated at component level.	Form, Fit, & Function constraints identified and allocated at sytem level.
	Unique Components		Unique components identified.	Unique component issues identified.	Plans completed to address unique component issues.
	Key Characteristics		Key Performance Parameters (KPPs) identified.	KPPs allocated at the component level. Initial evaluation of Key Characteristics (KC) accomplished.	Tolorances established for KC.
Materials	**Maturity**	Characterize basic materials for manufacturability	Completed survey to determine if materials have been used before in a mfg environment. Preliminary plans in place to address gaps.	Related material development efforts known. Maturity has been assessed on similar materials.	Maturity has been assessed on similar materials in production. Specific programs identified. Preliminary materail specifications in place.
	Availability	New material scale-up challenges assessed	All exotic/critical/ hazardous materials, and associated lead times have been identified. Significant material risks have been identified: high cost, availability, safety, health, hazards, etc.	Identify availability issues.	Complete a plan to address availability issues. Identify long lead items.
	Sources		ID sole source/single source/foreign source vendors.	Begin planning to minimizes sole/single/foreign sources.	Complete a plan that minimizes sole/single/foreign sources. Need for Sole/Single/ Foreign source justified. Identify potential alternative sources.
	Special Handling	Identify potential special handling concerns (i.e. shelf life, security, HMMP, HAZMAT, storage environment, etc.) Prepare MSDS as necessary.	Identify special handling reqts (i.e. shelf life, HMMP,SECURITY, HAZMAT, storage environment, etc.) Review and update MSDS.	Special handling gaps identified.	Complete a plan to address special handling gaps.

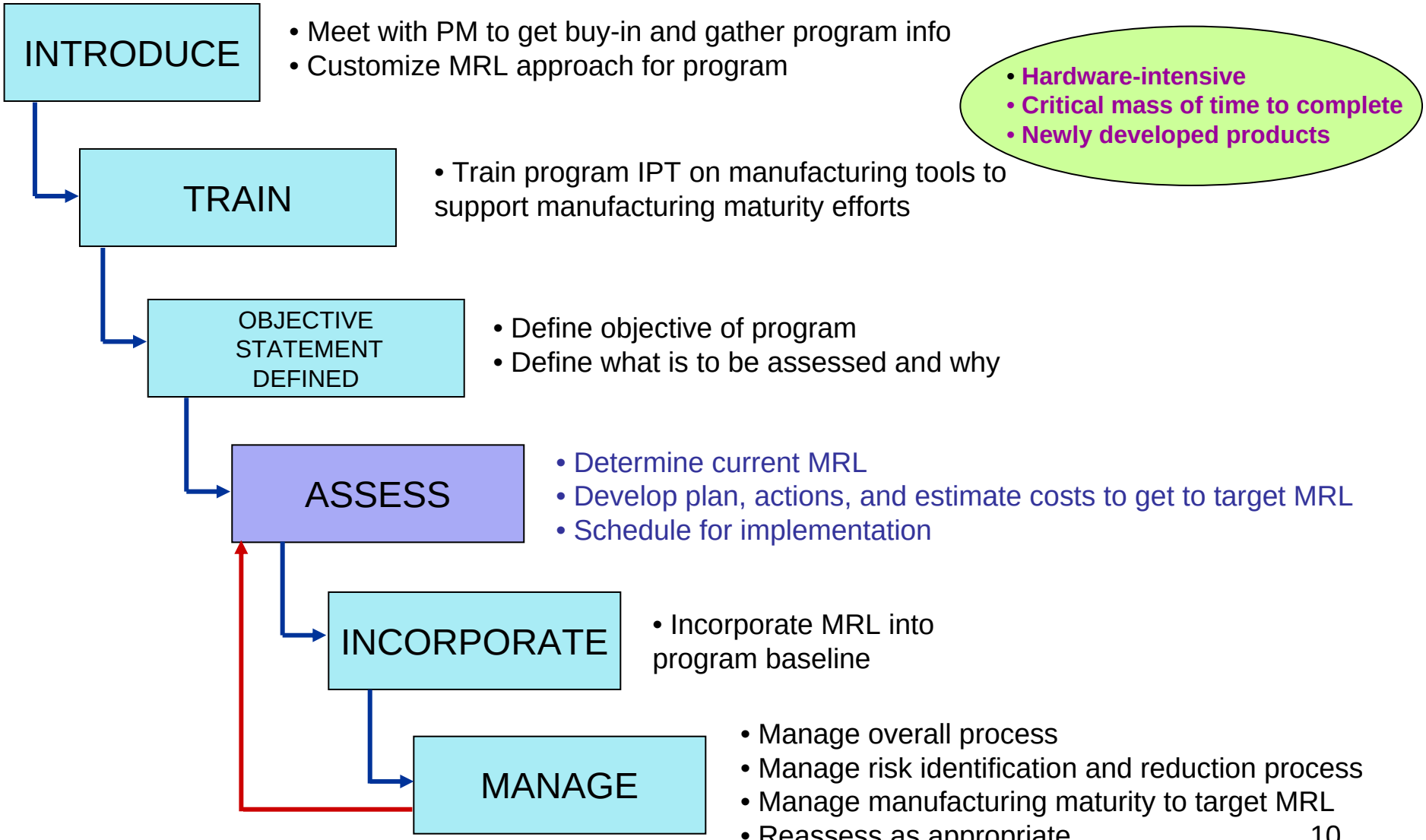
MRL definitions/threads

- Rewritten by MRL working group in July 07
  - Based on MRA experience to date
- Sponsored MRL workshop on 6-7 Sept 07
  - Government and Industry representatives
  - Scrub definitions/threads
  - AF Goal – easily used by S&T and Acquisition communities
- New definitions/threads to be published soon

MRL Implementation Approach

In partnership with Joint Defense Manufacturing Technology Panel (JDMTP)
  - Develop and MRL definitions & policy language
- Conduct pilots on various programs
  - Advanced Technology Demonstrators
  - Weapon System Acquisition programs
  - Demonstrate benefits of using MRL
- Conduct training for key program personnel
  - What are MRLs, how to conduct an MRA
    - Air Force ManTech personnel
    - ATD and ACAT pilot program personnel
    - Various training materials that can be tailored
  - Transition to DAU once MRLs are in policy
- Put MRLs into policy
  - AFRL, AFMC, AF, OSD

Manufacturing Readiness Level Implementation
Approach (ATDs)



MRA Deliverables

- Identification of ***current MRL***
- Identification of key factors where manufacturing readiness falls short of ***target MRL***
  - Define driving issues
  - Define high risk areas
- Identify programs and plans to reach target MRL
  - Generate the manufacturing maturity plan (MMP)
- Assess type and significance of risk to cost, schedule and/or performance

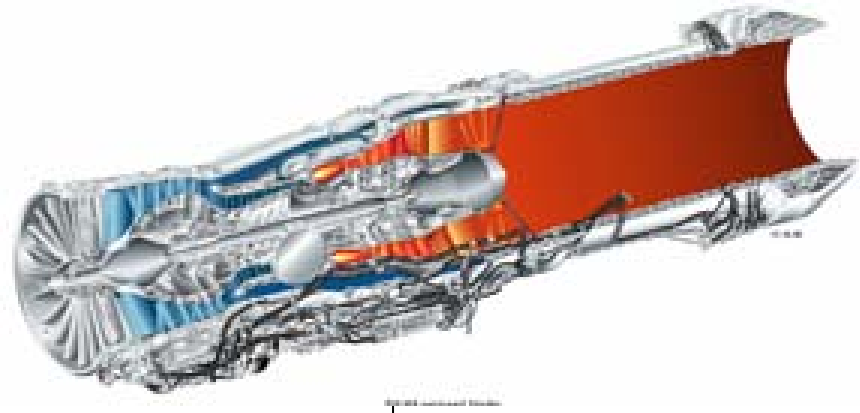
Emerging MRA Successes

High Durability Hot Exhaust Structures

- Provided identification of high risk processes and single point failures driving scale-up from MRL 3
- Maturation plan provides awareness of issues relating to move to new production facility
- Follow-on MRA at new facility will help ensure transition success

F135

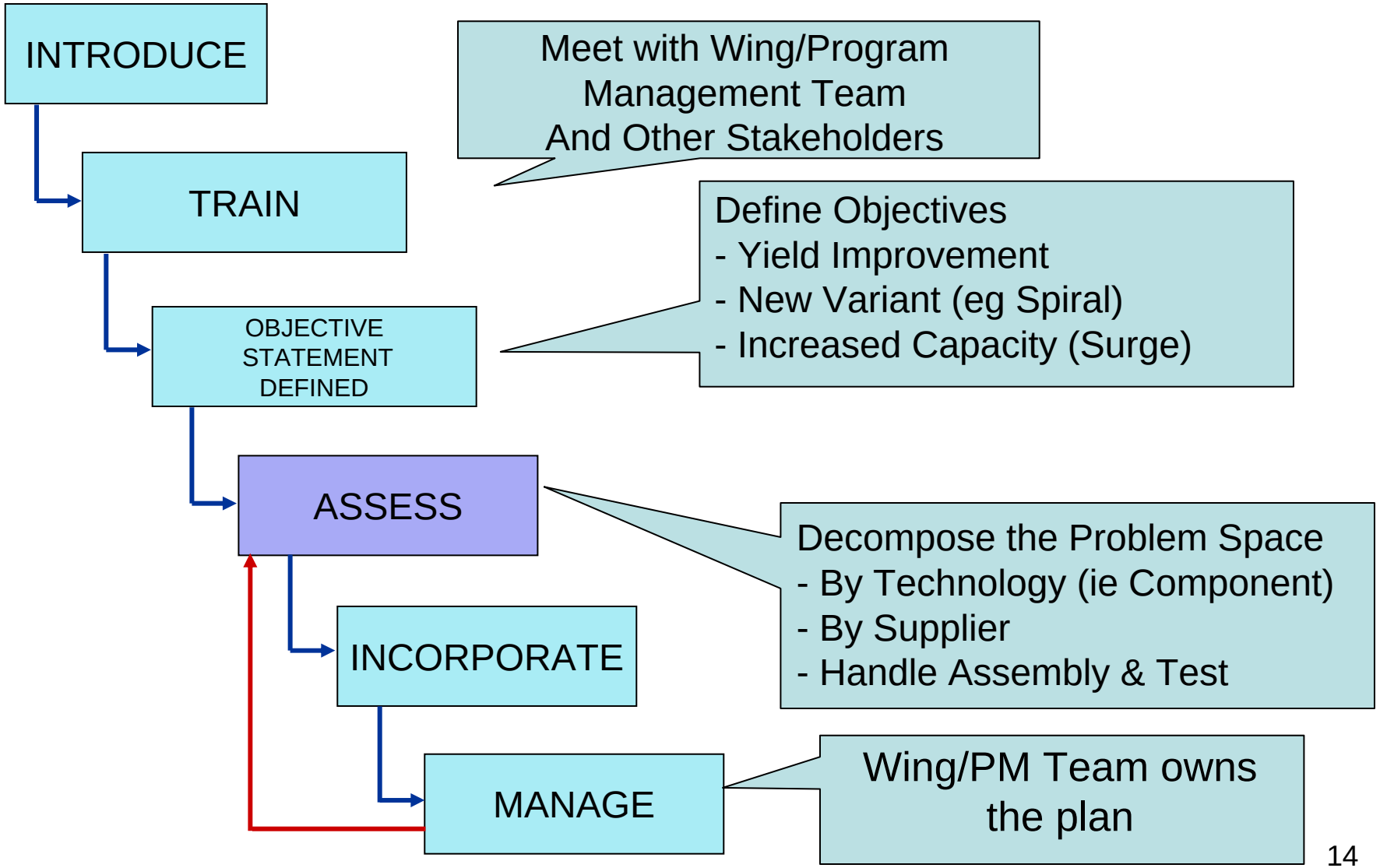
- Enabling opportunity to accelerate transition for F135 thrust improvement by ~4 years
- Advanced feature high cost driver: must overcome producibility issues
- Developed plan to mature from MRL 3 to 5 leveraging commercial and military IR&D, F135 program, and ManTech funding



ACAT MRA Pilot

- **Translate the successful MRL ATD process to acquisition programs**
- **Common themes**
  - **Utilize approximately the same process**
  - **Utilize current MRL definitions to assess against**
  - **3-5 people per MRA**
- **What is different**
  - **ATDs focusing on MRL 3 – MRL 6**
    - **Assessing technical maturity with a goal of transition/implementation**
  - **ACATs focusing on MRL 4 – MRL 9**
    - **Schedule, cost, manning considerations**
    - **Milestone decisions**
    - **Production planning process**
    - **Will require a more rigorous approach**
- **Develop and document a structured ACAT assessment approach**
  - **MRA Deskbook**
    - **First draft completed Mar 07 based on ATD and limited ACAT experience**
    - **Drafted with SAF/AQRE, MRL Working Group, and ASC/EN**
    - **Test drive on Reaper**
      - **Update based on lessons learned**

Manufacturing Readiness Implementation Approach (ACATs)



AMRAAM

- Manufacturing Readiness Assessment and process improvements of AIM-120 C-7
  - <u>What:</u> Performed a system-level MRA on the AMRAAM C-7 variant
    - Looked at all test and assembly steps, including FACO
    - Fourteen key suppliers; over thirty-five technology areas examined
  - <u>Impact:</u> Based on independent assessment, AMRAAM Group received go-ahead to proceed to next production lot for C-7 variant; reduced testing cycle time in particular cell by 90%

MRL/MRA Training

- Air Force ManTech Personnel
  - Industrial Preparedness
  - MRL/MRA methodology
  - Continuing education
  - Subject Matter Experts
    - Six sigma
    - Lean

- ATD IPTs
  - MRL definitions and MRAs
  - Training can be tailored for various audiences
- Air Force Product Centers
  - Based on ATD training with lessons learned from ACAT experience
  - DAU
    - Currently in PQM 201, SYS 302, and PQM 301

Policy Formulation Status

- DoD
  - Policy language written by MRL working group
  - OSD motivated to get policy in place by end of Sept 07
  - Initial policy likely to come out as a letter signed by Mr. Young
    - Actual policy, not guidance
  - Following policy letter
    - DAG
    - 5000.2
  - We are available to support as required
- AF
  - SAF/AQR team leading the charge
    - Goal to issue guidance by 1 Jan 08
    - Policy memo signed my Ms. Payton
    - Put into systems engineering, AFI 63-1201
    - Working with AQR to implement

MRA Deskbook

- The “how-to” of MRAs
- First draft completed in March 07
- Modeled after TRA Deskbook
  - Similarities
    - Achieving levels of readiness for risk reduction
    - Selection process for CTEs
  - Differences
    - Readiness in S&T and Acquisition world
    - Rigorous assessment process
- Next draft based on lessons learned from Reaper MRA
  - Dec 07, Public releasable

Lessons Learned

- MRLs are not a report card
  - ***MRL 7 might not be good***
  - ***MRL 3 might not be bad***
- MRLs are a tool to manage and mitigate manufacturing risk
  - ***A common language used to assess manufacturing maturity***
  - ***Provide insight not <u>oversight</u>***

Future Steady State

- Programs utilizing MRLs
  - Funding MRL maturation
  - Understanding of manufacturing concepts
- Use of MRLs in policy
  - Program offices staffed/trained
  - Manufacturing a key component to MS reviews
- Training
  - DAU acts as the primary government training agent
  - Air Force supports training updates

Additional Information

- MRL definitions can be found at DAU web site:
  - https://acc.dau.mil/CommunityBrowser.aspx?id=18231
    - Look for MR definitions
    - Look for MR matrix
    - Look for MRL tutorial
- Google – manufacturing readiness assessments

In Closing

- Using a three-pronged approach to implementation
  - Piloting and incorporating into various programs
  - Training
  - Policy insertion
- Overall implementation progressing
  - Air Force
  - DoD
- We are still learning and applying lessons learned

Air Force is Leading DoD-wide Implementation

BACKUP

MRL/MRA Implementation across DoD

	ATDs	ManTech	SBIR	Acquisition	Policy	Other
Army	●	●	◑	◑	○	AIDE Program
Navy/USMC	○	○	○	○	○	Assist Tool
Air Force	●	●	◑	◑	◑	Title III
DLA	N/A	◑	◑	N/A	○	
MDA	N/A	●	○	◑	●	
DARPA	○	N/A	○	N/A	○	

● MRLs

● EMRLs